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Trias. Above these lie Jurassic, Cretaceous, some small patches of Tertiary strata, and, on the higher elevations, glacial deposits.

The pre-Cambrian rocks and the intruded gabbro are the most important from the standpoint of the economic geologist, for it is with these that the ore deposits are connected.

As indicated by the title of the paper, copper ores are the chief ores of this district, though some lead and silver, and a trifling amount of gold, in quartz veins, have been found. The copper minerals comprise chalcopryrite, bornite, chalcocite, and covellite, with their usual alteration products. The principal gangue minerals are quartz, calcite, siderite, feldspar, hornblende, epidote, and garnet.

Some of the metallic sulphides crystallized contemporaneously with the silicate minerals of the rocks; others are supposed to be of later origin, and to have been formed by impregnation of the schists by the intrusive norite. A common origin by aqueous deposition is assigned to the remaining ores, and they are found in all channels of easy circulation. Their ultimate source is attributed to the basic igneous rocks of the region, which contain appreciable amounts of copper, and in many cases cobalt and nickel as well.

The most important ores commercially are those (chalcocite) found along the bedding planes and brecciated zones in the pre-Cambrian quartzite. Here secondary enrichment has taken place.

W. D. S.

Recent Seismological Investigations in Japan. By BARON DAIROKU KIKUCHI. Private Publication.

THIS important paper was prepared as an address to be delivered at the Congress of Arts and Science at St. Louis, but, as the author was unexpectedly prevented from attending the Congress, it was printed privately and distributed by him. It is, however, a much more elaborate paper, and much more amply illustrated, than would be inferred from the statement that it is an address. It covers 145 pages, and is accompanied by 54 illustrations relating to earthquake effects, earthquake-proof structures, instruments of observation and their records, geographic distribution, and related subjects. The paper sets forth with much fulness the work of the Earthquake Investigation Committee of Japan in connection with the Seismological Institute of the Tokyo University—work which must be regarded as among the most important now in progress. A chapter is given to the geographical and chronological distribution of earthquakes—

subjects to which the records of this "land of earthquakes" make exceptional contributions. Under the time distribution, the annual, diurnal, lunar, and other periodicities are considered. The most impressive feature of the geographical distribution lies in the fact that the frequency of the Japanese earthquakes increases toward the sea border, especially toward that portion of it which overlooks the great "deeps," and not toward the mountainous axis of the islands.

The instruments used in Japanese investigations are described, illustrated and discussed, as well as the nature of the oscillations which they detect and record.

In the discussion of the velocities of propagation of the seismic vibrations to distant points, preference is given to the view that the paths are essentially parallel to the surface, and not chords, as held by Milne, Knott, Dutton, and others (see previous review). The grounds for this are not made quite clear; at least they are not quite clear to the reviewer. The view involves the supposition that the ratio of elasticity to density in the different horizons near the surface of the earth varies so greatly that, while the main vibrations move at about 3.3 kilometers per second, the advance tremors move at about 14 kilometers per second, or more than four times as rapidly. Professor Nagaoka's investigations of the elastic constants of rocks (see table in Dutton's work, pp. 230, 231) give computed velocities for the fastest or normal wave ranging from 1.19 to 7.05 kilometers per second, the average of sixty-seven determinations made upon various surface rocks being 3.85 kilometers per second. When some little allowance is made for the fractured condition of the crust, this tallies well with the observed superficial rate of propagation, 3.3 kilometers per second. Selecting the Archean and eruptive rocks as being more nearly representative of the material of the sub-crust, eighteen determinations give an average velocity of only 3.75 kilometers per second. The compact Paleozoic rocks prove to be as elastic as the eruptives. The average of the highest eight of the whole list is only 4.95, or a little more than one-third the maximum velocity of the preliminary tremor. If the velocities of these select examples were computed for an unlimited rock medium, instead of a bar, they would average 5.79 kilometers per second, which is still less than half the requisite velocity. As no single rock was found to have much more than half the requisite velocity computed on the assumption that the preliminary tremors went around the spheroid parallel to the surface, and as the speed of the fastest form of wave in an unlimited medium of *steel* under surface pressure is theoretically only about 6.2 kilometers per second, it seems a rather arbitrary assumption that any substratum in the outer part of the earth

would give so high a velocity as 14 kilometers per second. On the supposition that the line of propagation is a chord, a velocity of 9.25 kilometers per second is required, which might more easily be supposed to be supplied by the high pressure of the deep interior, since pressure seems to increase rigidity faster than it does density (Dutton's work, p. 234). The most probable path is a chord-like curve convex toward the center of the earth, so chosen automatically by the wave as to give the most effective combination of shortness of path and superior elasticity, since the latter probably increases toward the center so as more than to overbalance the increased density. So far as giving us light on the physical condition of the interior is concerned, it is of the most vital importance that the correct interpretation of the path pursued by the vibrations be entertained.

The address brings out the gratifying fact that collateral investigations on the associated geological conditions, the earth's magnetism, gravity, underground temperature, and other related subjects, are being made by the Earthquake Investigation Committee. They are also engaged in practical studies for the reduction of the disastrous effects of earthquakes, and structural plans for houses are discussed and illustrated in the paper.

T. C. C.

Earthquakes in the Light of the New Seismology. By CLARENCE EDWARD DUTTON, Major U. S. A. New York: G. P. Putnam's Sons; London: John Murray, 1904.

THIS is a very lucid, appreciative, and trustworthy exposition of the recent important advances in seismology, and is in every way a most welcome contribution to the literature of the earth-sciences. Geologists have only partially realized the profound contribution which the new seismology is in process of making to the fundamental concepts of geology. It is perhaps necessary to guard the statement by saying that seismology is in the process of making, rather than has already made, a profound contribution to geologic fundamentals, for the contribution is dependent on the correctness of the belief that seismic vibrations pass *directly through* the body of the earth, as well as around its surface, and that the traversing waves are those that are first recorded by seismographs at distant points on the surface. It cannot as yet be absolutely affirmed that these preliminary vibrations actually traverse the deep interior. This is the interpretation of most of the leading seismologists, and is probably the correct one. Still it must be recognized that this is not yet proved, and that Baron Kikuchi (see preceding review) and others hold the view that these vibrations pass